### Improvement of safety in densely built-up areas

### 1. Outline of Studies and Activities

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| Background event   | Subject  | Main research   | Reflection of results   |
| (January 1995)<br>Southern Hyogo<br>Prefecture Earthquake<br>(May 1997)<br>Enforcement of the Act  | Mainstreaming the<br>formation of urban fire<br>protection zones by<br>developing fire spread<br>barrier zones to prevent<br>large urban fires |   |   |
| on Promotion of<br>Improvement of<br>Disaster Control<br>Districts in Populated<br>Urban Districts<br>(December 2001)<br>Urban Renewal Project | in densely built-up areas.<br>Urgent need to improve<br>disaster prevention in<br>densely built-up areas.                                      | <ul> <li>Development of Assessment and<br/>Countermeasure Technologies for<br/>Disaster Prevention in Town Planning<br/>(1998-2002), etc.</li> <li>Development of an index (fire spread</li> </ul>  | •Fire spread resistance rating is<br>positioned as a criterion for<br>selecting densely built-up areas<br>that are extremely dangerous.   |
| (Third Decision)<br>-Elimination of<br>dangerous urban areas<br>with a particularly<br>high potential for<br>large fires<br>(1 = 2022)         | Accelerate measures for<br>densely built-up areas by<br>establishing specific<br>districts.  | resistance rating) to identify fire hazard areas<br>• Development of a fire simulator to evaluate<br>the fire prevention performance of buildings in<br>densely built-up areas where fire prevention<br>performance needs to be improved, etc.  | <ul> <li>Creation of Specified Disaster<br/>Prevention Zone Improvement<br/>Districts</li> <li>Improvement of fire protection<br/>performance when quasi-fireproof<br/>buildings are required is clarified<br/>using an urban fire simulator.</li> </ul>  |
| Revision of the Act on<br>Promotion of<br>Improvement of<br>Disaster Control<br>Districts in Populated   | Traditional skeletal public<br>investment-type<br>improvements such as<br>road widening, park<br>improvements, and joint                       | <ul> <li>Study on Fromoting Methods for<br/>Realizing Safety in Densely Inhabited<br/>Areas (2004-2005)</li> <li>Study of reconstruction promotion measures by<br/>utilizing the special exception method of the<br/>group provisions of the Building Standards Law<br/>(Urban development guidance method)</li> </ul>                      | Publication of "Guidebook on<br>Special Permissions in the  |
| Urban Districts<br>-Creation of Specified<br>Disaster Prevention<br>Zone Improvement<br>Districts<br>(March 2011)                              | reconstruction<br>U<br>Detailed improvement<br>measures within city<br>blocks, such as the use of<br>regulatory guidance<br>methods, are also  | <ul> <li>Street scenery improvement district planning</li> <li>Special permission for allowable building coverage ratio</li> <li>Paragraph 3 Roads (horizontal distance designation)</li> <li>Combination building design system</li> <li>Permission under Article 43</li> </ul>  | Zoning Code under the<br>Building Standards Law to<br>Promote Rebuilding in Densely<br>Built-Up Areas," NILIM<br>Technical Note No. 368, 2007<br>Continue to provide technical<br>support to local governments  |
| (March 2011)<br>2011 Tohoku Pacific<br>Coast Earthquake<br>(March 2011)<br>Basic Plan for Housing<br>and Pacolo                                | important.   | Development of Support System on Making<br>Harmonious Rules for Rebuilding in Densely<br>Built-Up Areas (2010-2013)     The project proposed a simple method for<br>predicting and comparing the level of   | that promote improvement of<br>densely built-up areas through<br>workshops and on-site lectures,<br>etc.  |
| (Nationwide Plan)<br>-Elimination of "densely<br>built-up areas that are<br>extremely dangerous<br>in the event of an<br>earthquake, etc."     |  | performance* of a district after reconstruction<br>based on "the harmonious rules for rebuilding,"<br>using exceptional methods for harmonious<br>rebuilding, based on a model that simplifies the<br>spatial factors of an urban area to a certain extent.<br>*Fire prevention, evacuation, shading, lighting,<br>ventilation, and airflow | <ul> <li>Reflected in the 2018 amendments<br/>to the Building Standards Law</li> <li>Drafting of the approval criteria<br/>(Ministerial ordinance) for the<br/>revision of Article 43, Paragraph 2<br/>(Streamlining of procedures for<br/>exemption from the application of<br/>road connectivity restrictions)</li> </ul> |
| (April 2016)<br>2016<br>Kumamoto<br>Earthquake<br>(December 2016)<br>Itoizawa City Large-  |  | <ul> <li>Examination of the fire spread mechanism of<br/>the Itoigawa Large Fire (2016-2017)</li> <li>Verification of the effect of designating quasi-<br/>fire-protection districts using an urban fire<br/>simulator</li> </ul>   | Revision of Article 53     (Requirements for relaxation of<br>allowable building coverage ratio<br>restrictions)     •Publication of "Guidebook on<br>Special Permissions in the Zoning   |
| scale fire<br>(March 2021)<br>Basic Plan for Housing<br>(Nationwide Plan)  | Hard measures  | <ul> <li>Analysis of utsinectrive for improvement of<br/>densely built-up areas and compilation of<br/>advanced case studies (2016-2020), etc.</li> <li>Analyze disincentives for improvement of<br/>densely built-up areas from multiple</li> </ul>  | Code under the Building<br>Standards Law to Promote<br>Rebuilding in Densely Built-Up<br>Areas" [Revised version, June<br>2019]. NILIM Technical Note No.   |
| -Continue to eliminate<br>"densely built-up<br>urban areas that are  | +<br>Strengthening soft<br>measures  | perspectives, and prepare a collection of<br>advanced case studies on detailed and effective<br>improvement measures and support measures<br>according to regional characteristics.   | Support for policy planning by the  |
| extremely dangerous<br>in the event of an<br>earthquake, etc." and<br>strengthen soft  |  | Research and reflection of results on fire<br>prevention performance evaluation using<br>extraction indices and simulation technology<br>in densely built-up areas  | <ul> <li>Ministry of Land, Infrastructure,<br/>Transport and Tourism by providing<br/>analysis results and case studies</li> <li>Technical support to local governments<br/>through publication on the NILIM<br/>website seminars and on-site lectures</li> </ul>   |
| measures   |  | measures to improve disaster preparedness in<br>densely built-up areas  | etc.  |

#### 1) Background Events, Social Changes, etc.

#### (Elimination of densely built-up areas is also an issue in urban disaster prevention measures)

Prior to the Southern Hyogo Prefecture Earthquake in 1995, urban disaster prevention measures mainly focused on preventing large urban fires by establishing fire spread barriers consisting of wide roads, fireproof buildings along the roads, rivers, and railroad beds at the city level. The effectiveness of fire spread barrier zones was reaffirmed by the fact that the fire that broke out during the earthquake was contained by wide roads, but the collapse of buildings and damage caused by fire in densely built-up areas was remarkable. In addition to conventional city-level measures, district-level measures to improve the safety in densely built-up areas have since become a major pillar of urban disaster prevention measures.

Under these circumstances, the Act on Promotion of Improvement of Disaster Control Districts in Populated Urban Districts was enacted in 1997, and the improvement of densely built-up areas began in earnest.

#### (Accelerated elimination of densely built-up areas)

In 2001, the Urban Revitalization Project (third decision) designated 8,000 hectares of land as "dangerous urban areas with particularly high potential for large fires" and set a 10-year target for the elimination of hazards in these areas. The 2003 revision of the Act on Promotion of Improvement of Disaster Control Districts in Populated Urban Districts established the "Specified Disaster Prevention Zone Improvement Districts," which requires buildings with fire prevention performance higher than quasi-fireproof buildings.

In 2011, the National Basic Plan for Housing for People (National Plan) set a target of eliminating approximately 6,000 hectares of "densely built-up areas that are extremely dangerous in the event of an earthquake, etc. (hereinafter referred to as "dangerous densely built-up areas")," taking into consideration not only fire danger but also evacuation difficulty, and specific measures have been promoted by the national and local governments.

Steady progress has been made in eliminating "dangerous densely built-up areas" and as of March 2021, the area had decreased to approximately 2,200 hectares. In order to eliminate the remaining areas, the new National Basic Plan for Housing for People (March 2021) stipulates the implementation of soft measures to further ensure safety, in addition to the continued implementation of minimum safety measures through hard measures.

#### (Large urban fires)

At the end of December 2016, a large-scale fire occurred in Itoigawa City, Niigata Prefecture. It was the largest fire in an urban area under normal circumstances since the Sakata Fire of 1976, reaffirming that large-scale urban fires can still occur under normal circumstances.

#### 2) Research Subject

Since its establishment in 2001, NILIM has continuously conducted research on the improvement of densely built-up areas. The major studies, which are listed in Table 1, can be broadly classified into ① research on extraction indices and fire prevention performance evaluation using simulation technology for densely built-up areas, and ② research on effective improvement promotion measures to improve disaster prevention based on the actual conditions of densely built-up areas. In addition, with regard to the fire that broke out in December 2016 in Itoigawa City, Niigata Prefecture, we are working with the Building Research Institute, National Research and Development Agency, to clarify the factors that led to the large-scale fire, including the assessment of damage through on-site surveys, confirmation of roof ignition through fire experiments, and verification of the effect of the designation as a quasi-fire-protection district through urban fire simulations.

#### 3) Outline of Research and Activities

In conducting the research, we worked closely with the Ministry of Land, Infrastructure, Transport and Tourism's Housing

Bureau, which is in charge of measures to promote the improvement of densely built-up areas, as well as local governments across Japan that have densely built-up areas and are working to improve them, and the Urban Renaissance Agency and universities. We have also developed technologies to support the Ministry of Land, Infrastructure, Transport and Tourism in making and evolving policies.

As mentioned above, the technological development conducted can be broadly classified into fire prevention performance evaluation and research on measures to promote improvement. From the viewpoint of technological development, the following issues were considered: measures to increase the "potential" as well as the "necessity" of improvement; support for "soft" as well as "hard" improvement; improvement through "regulatory guidance" and "restoration" as well as "projects" and "modification"; improvement of "living environment" as well as "disaster prevention performance"; improvement by regional characteristics and urban area type of densely built-up areas; improvement by private sector activities as well as public initiative; and improvement based on the attributes of the landowners and leaseholders for the elderly, low-income residents, and others.

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| No.   | Implementation period   | Budgetary<br>classification | Subject for study   |  |  |
| (1) Re  | ① Research on fire protection performance evaluation using extraction indices and simulation techniques in densely built-up areas |                             |   |  |  |
| Study 1   | 1998-2002   | 総プロ                         | Development of assessment and countermeasure technologies for disaster prevention in town planning  |  |  |
| Study 2   | 2001-2003   | 事項                          | Development of technology to improve urban disaster prevention by analyzing the relationship between human suffering and urban structures during earthquakes  |  |  |
| Study 3   | 2007-2009   | 総プロ                         | Development of national land management technology aimed at disaster mitigation through advanced image processing (including development of a support tool for comprehensive fire control in urban areas) |  |  |
| Study 4   | 2014-2016   | 事項                          | Research on the vulnerability of cities to urban fires during earthquakes and evaluation of the effectiveness of disaster prevention measures   |  |  |
| Study 5   | 2017-2019   | 事項                          | Development of technology for diagnosing possibility in the event of earthquakes and fires  |  |  |
| 2 Research on effective improvement promotion measures for disaster prevention based on the actual conditions of densely built-up areas |   |                             |   |  |  |
| Study 6   | 2000-2003   | 住建                          | Survey of effective improvement in high-density urban residential districts   |  |  |
| Study 7   | 2004-2005   | 住建                          | Study on promotion methods for realizing safety in densely-inhabited areas  |  |  |
| Study 8   | 2007-2008   | 住建                          | Research on measures to promote the development of densely built-up areas through private sector vitality based on the needs of landowners, etc.  |  |  |
| Study 9   | 2009-2010   | 住建                          | Study on approaches to improve densely built-up areas through private sector vitality, based on the needs of the residents and property owners  |  |  |
| Study 10  | 2010-2013   | 事項                          | Development of support system in making harmonious rules for rebuilding in densely built-up areas   |  |  |
| Study 11  | 2011-2012   | 住建                          | Study on improvement of regional vitality and area management in densely built-up areas with declining birth rate, aging, and population decline  |  |  |
| Study 12  | 2013-2015   | 住建                          | Research on ways of supporting self-help rebuilding to promote fire prevention in densely built-up areas  |  |  |
| Study 13  | 2016-2020   | 住建                          | Research on carefully crafted ways of accelerating improvement in densely built-up areas  |  |  |

 Table 1 NILIM Studies Related to Densely Built-Up Area Measures

総プロ:総合技術開発プロジェクト、事項:行政部費 (事項立て)、住建:住宅建設事業調査

#### 2. Main Research Results

Development of the "Fire Spread Resistance Rating," an indicator used to identify fire hazard areas (Conducted in Study 1)

 When implementing countermeasures in densely built-up areas, it is necessary to diagnose the fire resistance of the area and select the areas to be addressed. In many cases, the "noncombustible area ratio" was used for the selection, but since there were only two categories of fire resistance for buildings (burnable and non-burnable



延焼抵抗率=1- クルーク化されたクレー部分の面積 地区の面積-大規模空地の面積 Figure-1 Summary of fire spread resistance rating

buildings), it was not possible to evaluate various buildings according to their fire resistance.

- The fire spread resistance rating was newly developed to subdivide the fire resistance of buildings into four categories (fireproof, semi-fireproof, fireproof, and other) and to take into account the immediate geographical location of the building.
- The fire spread resistance rating was used as one of the indices in the identification of densely populated urban areas at risk in the National Basic Plan for Housing for People (National Plan).

Development of an urban fire simulator (Conducted in Studies 1, 3, and 4)

• We have developed an urban fire simulator capable of evaluating detailed fire protection performance in densely populated urban areas that are dangerous from a fire protection standpoint. This simulator can estimate the fire spread from an arbitrary fire starting point by setting an arbitrary wind speed and direction, while taking into account the fire protection performance of each building, the location of the building, and the performance of its openings. The simulator makes it possible to compare the effects of improving urban areas.



Figure-2 Example of evaluation by urban fire simulator

 The results of the study using this simulator also led to the creation of the Specified Disaster Prevention Zone Improvement District System.

#### Verification of the effect of quasi-fire-protection district designation on a large fire in Itoigawa City, Niigata Prefecture

- NILIM and the Building Research Institute conducted an investigation into the factors that led to the spread of the fire and its cessation at the request of the Ministry of Land, Infrastructure, Transport and Tourism's Housing Bureau.
- The fire test revealed that the fire occurred in at least 15 locations, and that the majority of the buildings were wooden and were constructed in 1933. Fire experiments also revealed that many of the roofs were built in the early Showa period, and that there were gaps between the roof tiles due to torsion of the tiles, through which sparks from the fire could enter and ignite the roof.
- Although the area is designated as a quasi-fire-protection zone, it was found that many of the buildings did not meet the current fire prevention regulations. The spread of the fire was estimated using an urban fire simulator, and it was found that the spread would have been significantly reduced in both cases if the current fire prevention regulations were met and the roof tiles were of modern specifications.



(再現市街地) (裸木造を全て防火構造に変更)(市街地②+現代仕様瓦屋根) Figure-3 Estimated fire spread area if current fire prevention regulations are met (Source: Aerial photograph taken by GSI, 2009)

# ◆Preparation of "Guidebook on Special Permissions in the Zoning Code under the Building Standards Law to Promote Rebuilding in Densely Built-Up Areas" (Conducted in Study 7)

· In densely built-up areas, narrow roads and small lots make it difficult to comply with general local building regulations

(e.g., road connectivity regulations, slant plane restrictions for roads, building coverage ratio restrictions, etc.), which is one reason for the stagnation of rebuilding.

- As one of the solutions, we studied measures to promote rebuilding by utilizing special permissions in the zoning code under the Building Standards Act that can replace or relax some of the general building regulations, including street scenery improvement district planning, special permission for allowable building coverage ratio, Paragraph 3 Roads (horizontal distance designation), combination building design system, and permission under Article 43.
- The results were compiled and published as NILIM Technical Note No. 368, "Guidebook on Special Permissions in the Zoning Code under the Building Standards Law to Promote



、路地での建て替えを可能とした例。 Figure-4 Successful examples of rebuilding in dense urban areas using city planning guidance methods

Rebuilding in Densely Built-Up Areas" in 2007, and distributed to local governments with densely built-up areas nationwide. In addition, we continue to provide technical support to local governments that promote the improvement of densely builtup areas by holding seminars and on-site lectures.

- In 2019, ten years after the publication of the first edition, a revised edition of this guidebook was published to reflect revisions to the Building Standards Act and to include additional examples of the application of special permissions.
- Furthermore, the results of the survey on the actual utilization and intentions of special permissions for local governments with densely built-up areas nationwide are reflected in the consideration of the 2018 revision of the Building Standards Act

(Article 53 of the Act, review of the requirements for relaxation of allowable building coverage ratio restrictions).

### ◆Development of a town block performance evaluation method when applying special permissions in the Zoning Code under the Building Standards Law (Conducted in Study 10)

- We proposed a method to support simple prediction and comparison of performance levels (performance levels related to fire prevention, evacuation, shading, lighting, ventilation, and airflow) of a rebuilt city block, which is assumed to be reference information when considering "harmonious rules for rebuilding" using urban development guidance methods, based on a model that simplifies the local spatial factors of the city block to some extent.
- The "Reference for Prediction and Evaluation of Block Performance Levels in Densely Built-Up Areas to Support Making Harmonious Rules for Rebuilding in Densely Built-Up Areas" (Trial version) was developed through actual measurements
  - of block performance levels in each type of densely built-up area in cooperation with local governments and local community associations, surveys of residents' awareness, development of the "Simple Prediction and Evaluation Program for Block Performance Levels in Densely Built-Up Areas," and case studies. NILIM Technical Note No. 928 "Development of the Support System for Making Harmonious Rules for Rebuilding in Densely Built-Up Areas" was compiled and published in 2017.



Figure-5 Proposed flow of evaluation of city block performance levels

## ◆ Analysis of disincentives for improvement of densely built-up areas and preparation of case studies of countermeasures (Conducted in Study 13)

 The factors hindering the improvement of densely built-up areas are various, including narrow sites, sites with poor connectivity to roads, complex right-of-way relations such as leased land and leased houses, aging landowners and

householders, lack of finances government and manpower, and declining regional potential. In addition, these conditions vary from district to district, with trends differing between Kanto, Kansai, and other regions.

 

 In order to promote early
 (協支援制度: ①行政のマン

 improvement of disaster
 ①行政のマン

 prevention performance in densely built-up areas under the severe manpower and
 ■決定的な阻害要因である(100pt)



■決定的な阻害要因である(100pt) ■大きな阻害要因である(80pt) ■あまり阻害要因ではない(20pt) ■阻害要因ではない(0pt)] Figure-6 Factors hindering the development of densely populated urban areas at risk as considered by local

governments in the Kansai region and the degree of their influence

financial constraints of local governments, it is considered effective to combine conventional public investment in the framework (the "outer part"), such as the construction of a certain scale of roads and parks and joint rebuilding, with detailed improvement measures for disadvantaged sites such as the use of regulatory guidelines to improve the inner part (the "stuffing") and the use of private sector vitality.

- NILIM therefore conducted a multifaceted analysis of impediments to the improvement of densely built-up areas that need to be eliminated, focusing on factors that hinder the daily business development of private companies that lead to the physical improvement of densely built-up areas and factors that delay the progress of improvement of dangerous densely built-up areas in the Kansai region compared to the Tokyo metropolitan area, etc. NILIM also conducted a survey of detailed and effective approaches to each impediment by local governments and private companies, and compiled a list of examples.
- By providing information on the results of the analysis of impediments to the improvement of densely built-up areas and improvement measures, NILIM supports the Housing Bureau of the Ministry of Land, Infrastructure, Transport and Tourism in making policies, and provides technical support to local governments by assisting them, publicizing them on the NILIM website, and holding seminars and on-site lectures.
- In addition, the results of the research conducted in this study on the permission criteria of specific administrative agencies nationwide regarding the operation of the proviso of Article 43 of the Building Standards Act were reflected in the preparation of the draft authorization criteria (Ministerial ordinance) regarding the 2018 revision of the Building Standards Act (Article 43, Paragraph 2 (Streamlining procedures regarding exemption from application of road connectivity restrictions)).

#### 3. List of Related Reports and Technical Documents

1) 総プロ Report on the "Development of Technology for Disaster Prevention Assessment and Countermeasures in Urban Development"

http://www.nilim.go.jp/lab/jdg/result.htm

- Report on the "Survey on the Building Damage by the Large Fire that Occurred in Itoigawa City, Niigata Prefecture on December 22, 2016," NILIM Technical Note 980 http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0980.htm
- 3) "Guidelines on Special Permissions in the Zoning Code under the Building Standards Law to Promote Rebuilding in Densely Built-Up Areas," NILIM Technical Note No. 368 http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0368.htm
- 4) "Development of the Support System on Making Harmonious Rules for Rebuilding in Densely Built-Up Areas," NILIM Technical Note No. 928

http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0928.htm

- 5) "Guidelines on Special Permissions in the Zoning Code under the Building Standards Law to Promote Rebuilding in Densely Built-Up Areas" [June 2019 Revised Version], NILIM Technical Note No. 1076 http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1076.htm
- 6) Report on the "Study of Area Management Methods in Dense Urban Areas" <u>http://www.nilim.go.jp/lab/jeg/erimane\_20130927.pdf</u>
- "Research on Urban Renewal Technologies (Chapter 2: Methods of Improvement of Dense Wooden Urban Areas Using Reverse Mortgages)," NILIM Project Research Report No. 5

#### 4. Future Outlook

The new Basic Plan for Housing for People (National Plan), decided by the Cabinet in March 2021, sets basic measures and targets for the formation of safe housing and residential areas, including the elimination of "densely built-up areas that are extremely dangerous in the event of an earthquake, etc." (2020: approx. 2,200 ha  $\rightarrow$  2030: generally eliminated), the strengthening of soft measures that contribute to improving local disaster prevention capabilities (2020: approx. 46%  $\rightarrow$  2025: 100%), and the promotion of the use of utility poles. In addition, the plan calls for the strengthening of soft measures that contribute to the improvement of local disaster preparedness (2020: approx. 46%  $\rightarrow$  2025: 100%), and the promotion of the use of no utility poles. The plan also calls for analyzing the current situation of narrow roads in residential urban areas, which have been formed in a chaotic manner as a result of urbanization, identifying areas where safety should be intensively secured in cooperation with disaster prevention and urban development departments, etc., and promoting measures to address this situation. In response to these measures and goals, NILIM will continue to work on research and improvement of methods for understanding the actual conditions of densely built-up areas, methods for evaluating disaster prevention performance, and effective measures for promoting improvement.